(1)

PET500 - Exam - fall 2021

(1)

1) 

1 → cap shale
2 - sst
3 → bed shale

→ $V_p = 1360 + 1.16 V_s$

→ $Z_p / Z_s = 2.15$

→ $\rho_1 = 2.45\ g/cm^3$

Z_p ? in cap-shale (Z_{p_1}) ⇝ $Z_{p_1} = \rho_1 V_{p_1}$

$$2.15 = \frac{Z_p}{Z_s} = \frac{V_p \rho}{V_s \rho} \Rightarrow V_s = \frac{V_p}{2.15}$$

$$\Rightarrow V_p = 1360 + 1.16\left(\frac{V_p}{2.15}\right)$$

$$V_p - \frac{1.16}{2.15} V_p = 1360$$

$$V_p\left(1 - \frac{1.16}{2.15}\right) = 1360 \rightarrow V_p = \frac{1360}{\left(1 - \frac{1.16}{2.15}\right)} \cong 2953\ m/s$$

$$\Rightarrow Z_{p_1} = 2953\ m/s \cdot 2.45\ g/cc \cong \boxed{7235\ AI}$$

2) Shale (1)
Sandst. (2)

$V_{p_1} = 2200\ m/s$ $V_{s_1} = 800\ m/s$ $\rho_1 = 2.4\ g/cc$

$V_{p_2} = 2400\ m/s$ $V_{s_2} = 1000\ m/s$ $\rho_2 = 2.1\ g/cc$

a) $K_{1,2}$, $\mu_{1,2}$? $\rho_s = 2.65\ g/cc \rightarrow \phi_2$?

$$\begin{cases} V_p = \sqrt{\dfrac{K + 4/3\mu}{\rho}} \rightarrow K = V_p^2 \rho - \frac{4}{3}\mu = V_p^2 \rho - \frac{4}{3}\rho V_s^2 = \rho\left(V_p^2 - \frac{4}{3}V_s^2\right) \\ V_s = \sqrt{\dfrac{\mu}{\rho}} \rightarrow \mu = \rho V_s^2 \end{cases}$$

Shale
$$\begin{cases} K_1 = (2.4e3)\cdot[(2200)^2 - \frac{4}{3}(800)^2] \cong \underline{9.57\ GPa} \\ \mu_1 = (2.4e3)\cdot(800)^2 = \underline{1.53\ GPa} \end{cases}$$

Sand (brine-saturated)
$$\begin{cases} K_2 = (2.1e3)\cdot[(2400)^2 - \frac{4}{3}(1000)^2] \cong \underline{9.3\ GPa} \sim K_w^* \\ \mu_2 = (2.1e3)\cdot(1000)^2 \cong \underline{2.1\ GPa} \sim \mu_w^* \end{cases}$$

(2)

$\rightarrow \phi_2 : \phi_{sst} = \dfrac{\rho_b - \rho_{ma}}{\rho_{fl} - \rho_{ma}} = \dfrac{2.1 - 2.65}{1.02 - 2.65} \approx 0.33 \rightarrow 33\%$

b) brine-sst → gas-sst , K_g^*? , $K_w = 2.5$ GPa , $K_s = 40$ GPa

(K_g and ρ_g = vacuum = 0)

$$\underbrace{\frac{K_w^*}{K_s - K_w^*}}_{\alpha} - \underbrace{\frac{K_w}{\phi(K_s - K_w)}}_{\beta} = \frac{K_g^*}{K_s - K_g^*} - \frac{K_g \nearrow 0}{\phi(K_s - K_g)}$$

✓ $\alpha = \dfrac{K_w^*}{K_s - K_w^*} = \dfrac{9.3 \text{ GPa}}{(40 - 9.3)\text{ GPa}} \approx 0.30$

✓ $\beta = \dfrac{K_w}{\phi(K_s - K_w)} = \dfrac{2.5 \text{ GPa}}{0.33(40 - 2.5)\text{ GPa}} \approx 0.20$

$\rightarrow (\alpha - \beta) \cdot (K_s - K_g^*) = K_g^*$

$\alpha K_s - K_g^* \alpha - \beta K_s + \beta K_g^* - K_g^* = 0$

$K_s(\alpha - \beta) - K_g^*(\alpha - \beta + 1) = 0$

$\Rightarrow K_g^* = K_s \dfrac{(\alpha - \beta)}{(\alpha - \beta + 1)} = 40 \text{ GPa} \left(\dfrac{0.30 - 0.20}{0.30 - 0.20 + 1} \right) \approx 3.6 \text{ GPa}$

$\Rightarrow \mu_g^* = \mu_w^* = 2.1 \text{ GPa}$

$\Rightarrow \rho_g^* = \rho_g \phi \nearrow 0 + \rho_{ma}(1 - \phi) = 2.65 \text{ g/cc} (1 - 0.33) = 1.78 \text{ g/cc}$

c) AVO $\rightarrow \begin{cases} V_{P_2\text{-gas}} = \sqrt{\dfrac{3.6 + 4/3(2.1)}{1.78}} \approx 1896 \text{ m/s} \\ V_{S_2\text{-gas}} = \sqrt{\dfrac{2.1}{1.78}} \approx 1086 \text{ m/s} \end{cases}$

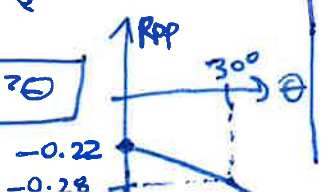
$\Delta V_p = 1896 - 2200 = -304$
$V_p = (1896 + 2200)/2 = 2048 \rightarrow \dfrac{\Delta V_p}{V_p} = -0.148$

$\Delta V_s = 1086 - 800 = 286$
$V_s = (1086 + 800)/2 = 943 \rightarrow \dfrac{\Delta V_s}{V_s} = 0.303$

$\Delta \rho = 1.78 - 2.4 = -0.62$
$\rho = (1.78 + 2.4)/2 = 2.09 \rightarrow \dfrac{\Delta \rho}{\rho} = -0.296$

$\Rightarrow$
$\rightarrow R_p = \frac{1}{2}(-0.148 - 0.296) = -0.22$
$\rightarrow R_s = \frac{1}{2}(0.303 - 0.296) = 3.5e-3$
$\rightarrow G = -0.22 - 2(3.5e-3) = -0.23$

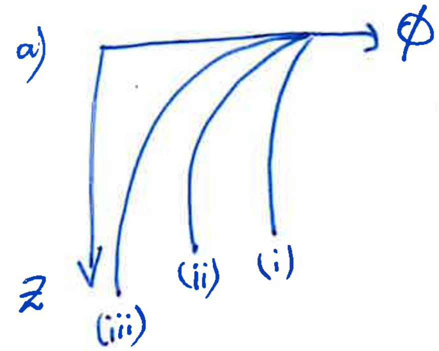
$\Rightarrow$ $\boxed{R_{pp}(\theta) \approx -0.22 - 0.23 \sin^2\theta}$



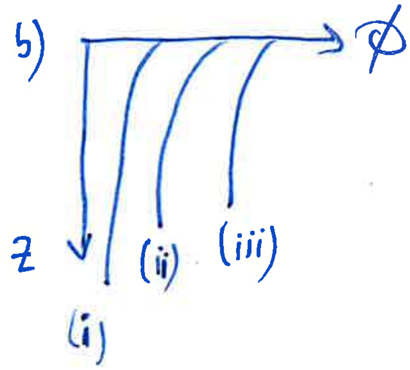
Class 3 : $R_p < 0$, $G < 0$

5) compaction studies

a) (i) dry smectite
(ii) oil-saturated smectite
(iii) brine-saturated Kaolinite



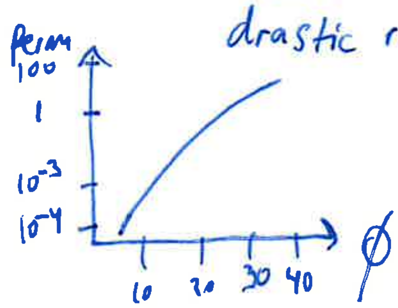
b) (i) brine-saturated qtz coarse sand
(ii) brine-saturated fine-sand
(iii) dry fine sand



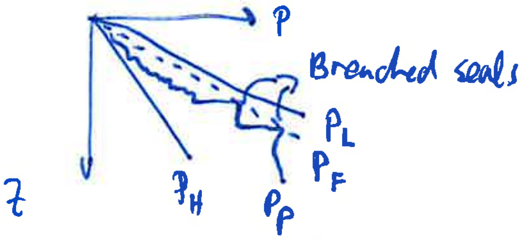
c) Kao/Smectite → illite

✓ illite is a pore-filling mineral → reduction in ϕ with a drastic reduction in permeability ↓ (logarithmic relationship)

a small ϕ loss might significantly reduce permeability



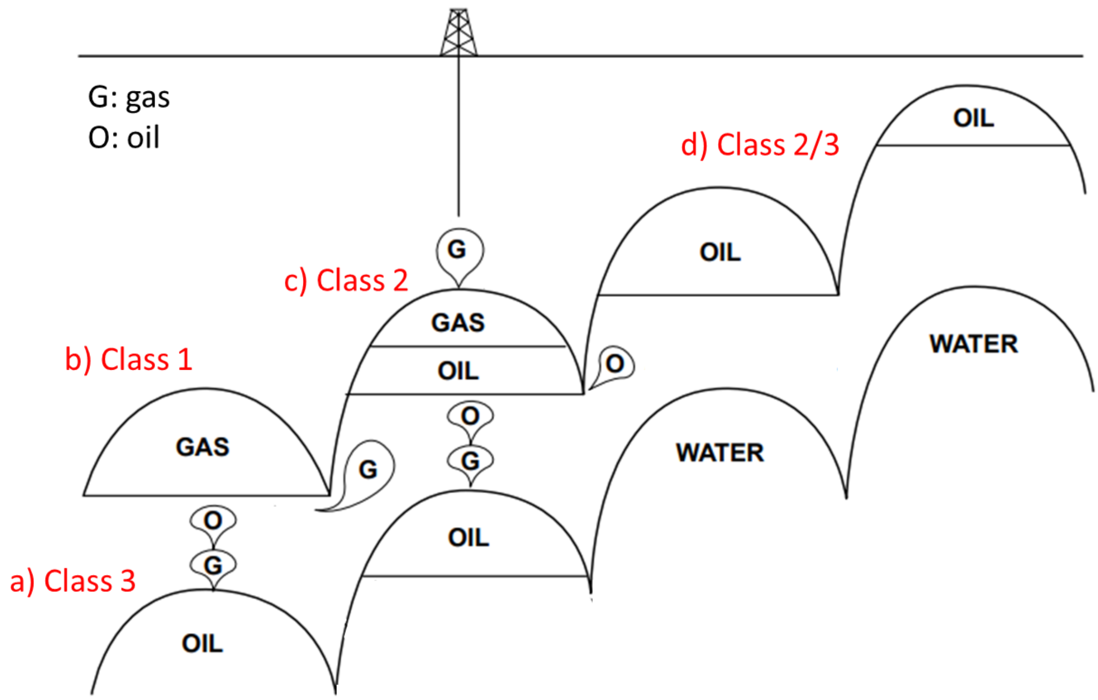
✓ Overpressure and cap failure
↳ illitization produces H_2O → increase in Pore Pressure.



4.

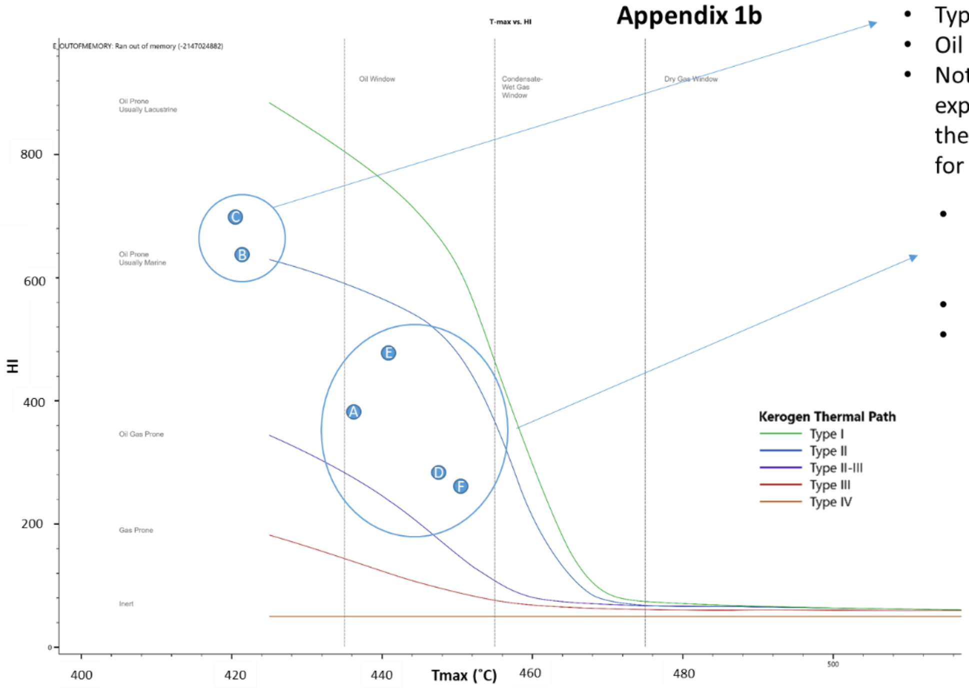
a) Sales (1997)

Appendix 1a



b)

Appendix 1b

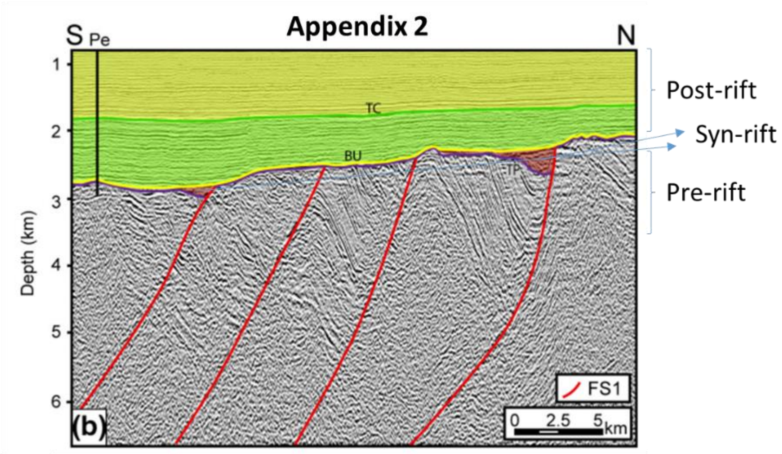


- Type I: Lacustrine
- Oil
- Not the source of this exploration scenario: they are not mature for HC generation

- Type II and II/III: marine and shallow marine environment
- Oil and gas
- Source of the exploration scenario: they are mature for HC generation

5.

a)



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PAPER

WILEY Terra Nova

Multistage rifting evolution of the Colorado basin (offshore Argentina): Evidence for extensional settings prior to the South Atlantic opening

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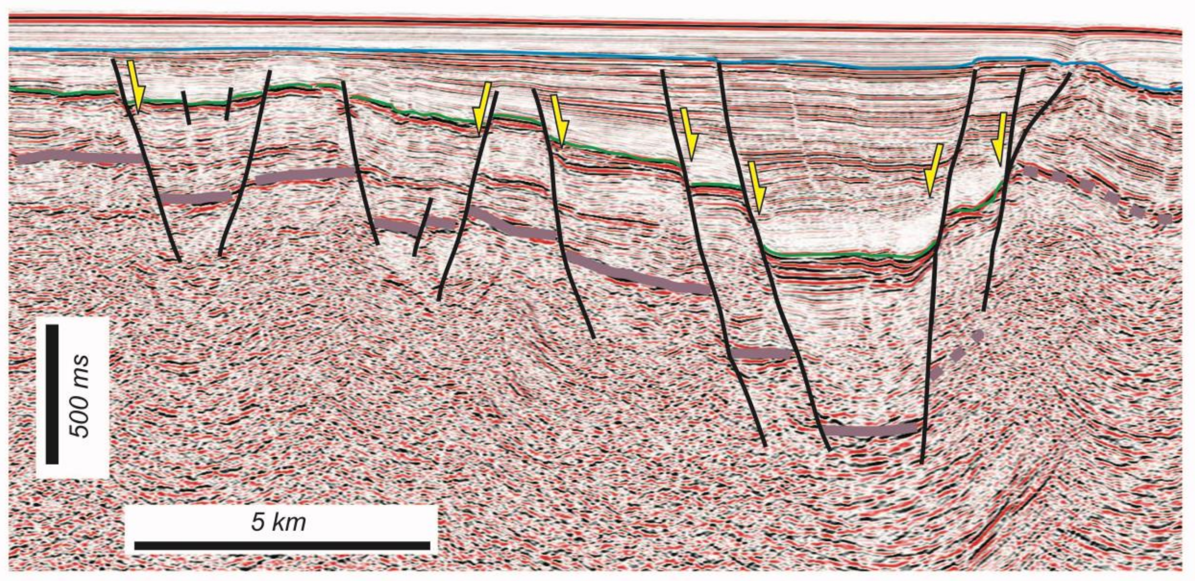
- Pre-rift: reflections showing rotated fault blocks
- Syn-rift: just the two small sediment wedges preserved on top of the pre-rift (in red raster)
- Post-rift: the sequences in green covering the underlying rift topography

b) https://www.seismicatlas.org/entity?id=0dbe8b16-2380-4927-a593-97a63d6caad7



For drilling for potential HC occurence in reservoirs: any rotated fault block in the figure, particularly in the edges of it…